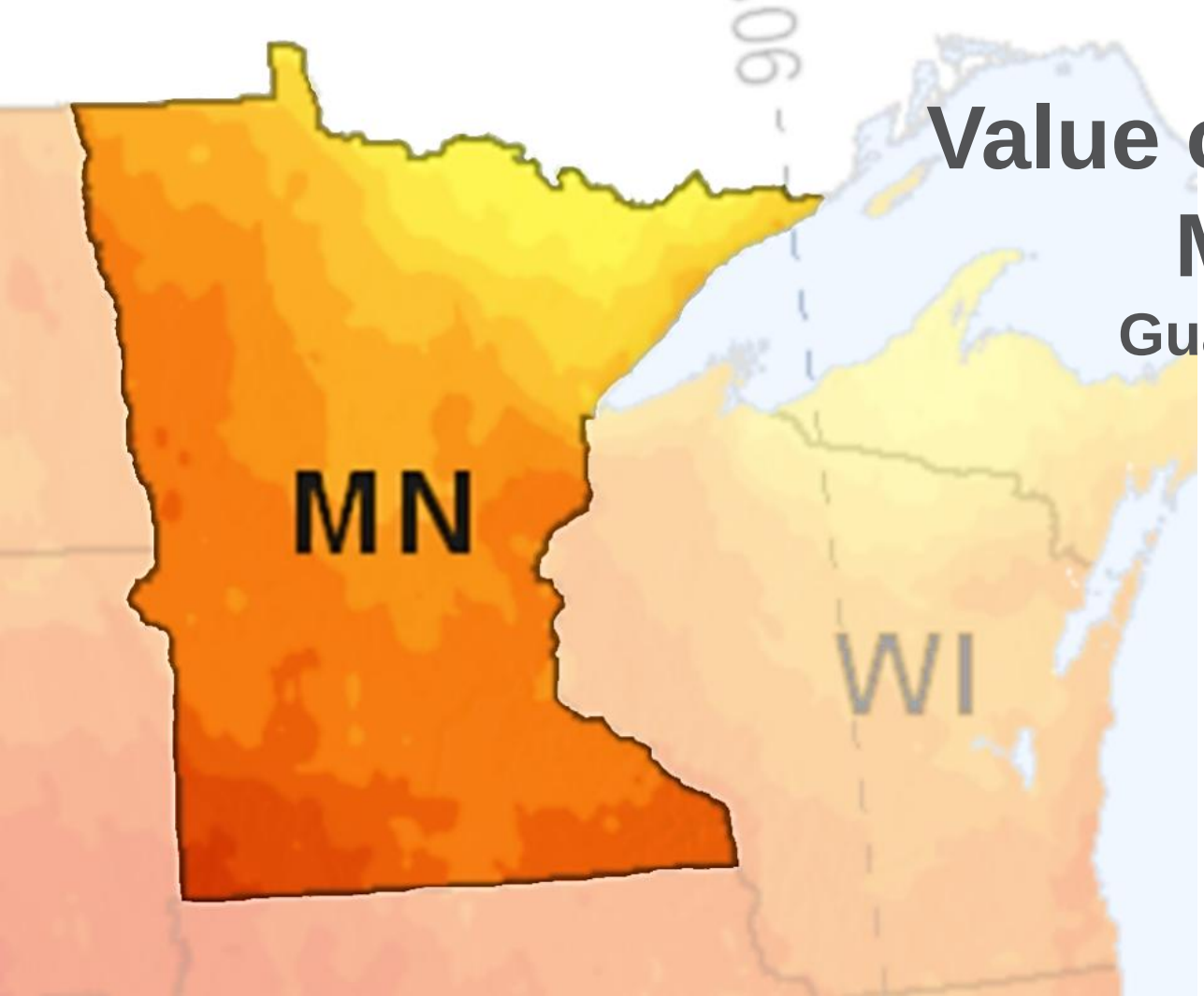


Value of Solar Tariff Methodology:

Guaranteed Fuel Value

October 15, 2013

Prepared for

Minnesota Department of Commerce, Energy Division

Prepared by

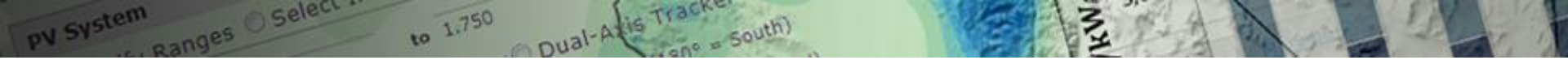
Clean Power Research

What Is Avoided Fuel Cost?

- Definition

  Benefit from distributed PV generation's offset of wholesale energy purchases

- Methodology
  1. Estimate solar weighted heat rate
  2. Combine with natural gas prices
  3. Calculate discounted value
  4. Levelize results
  5. Note: The methodology also requires an adjustment to account for marginal energy loss savings (not covered in this presentation)

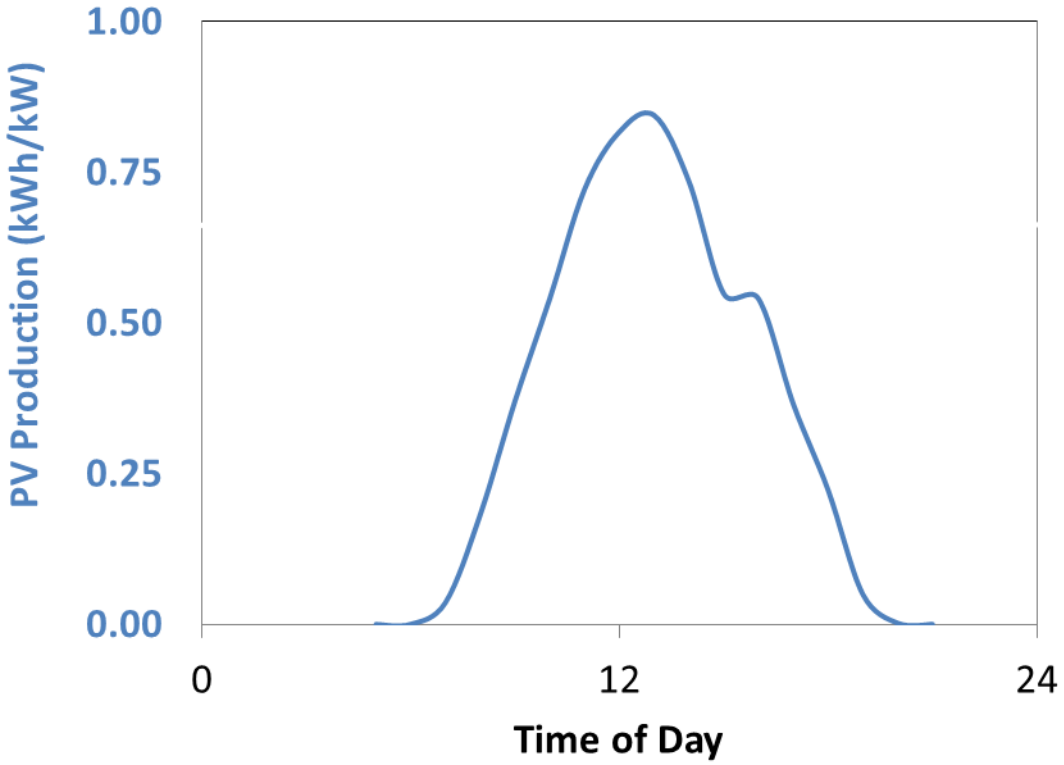


Estimate Solar Weighted Heat Rate

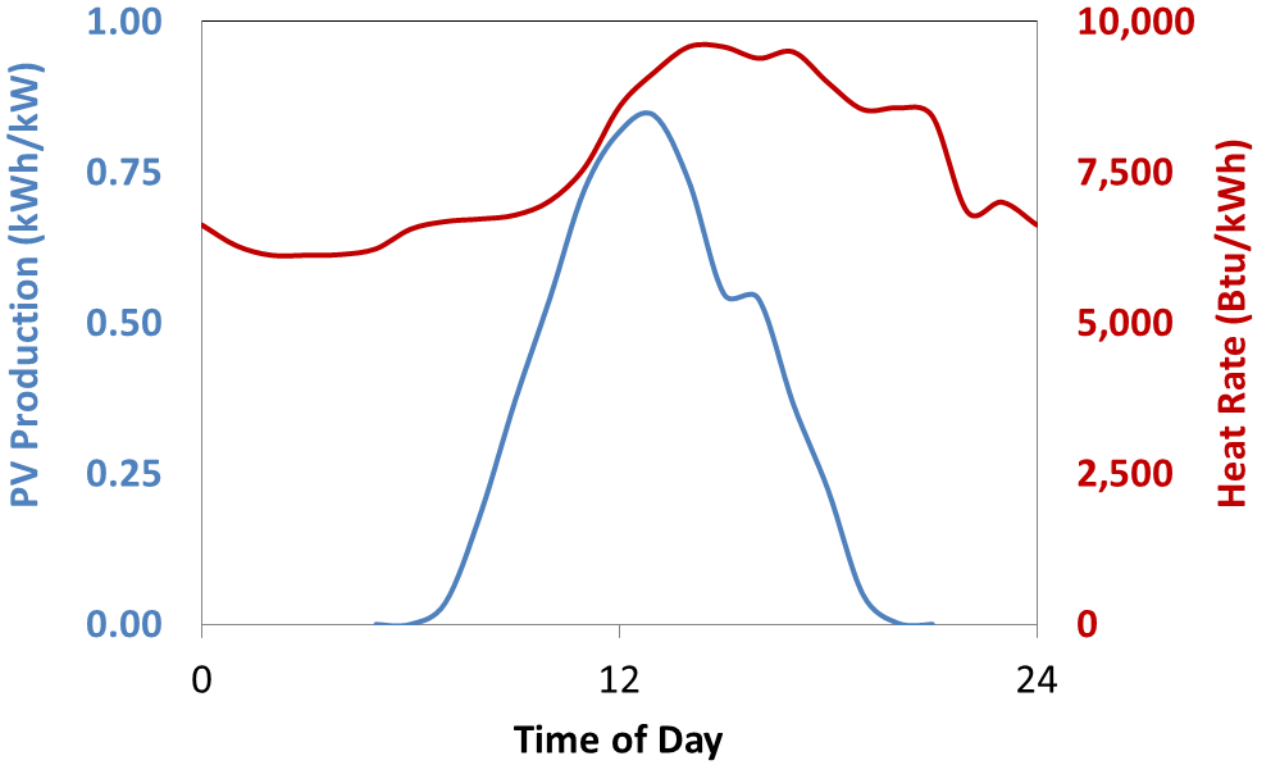
- Option 1: Assume ***Solar Weighted Heat Rate*** equals the heat rate with a specific unit, such as a CCGT

- Option 2: Calculate ***Solar Weighted Heat Rate*** using hourly marginal heat rates that are time-correlated with hourly PV output

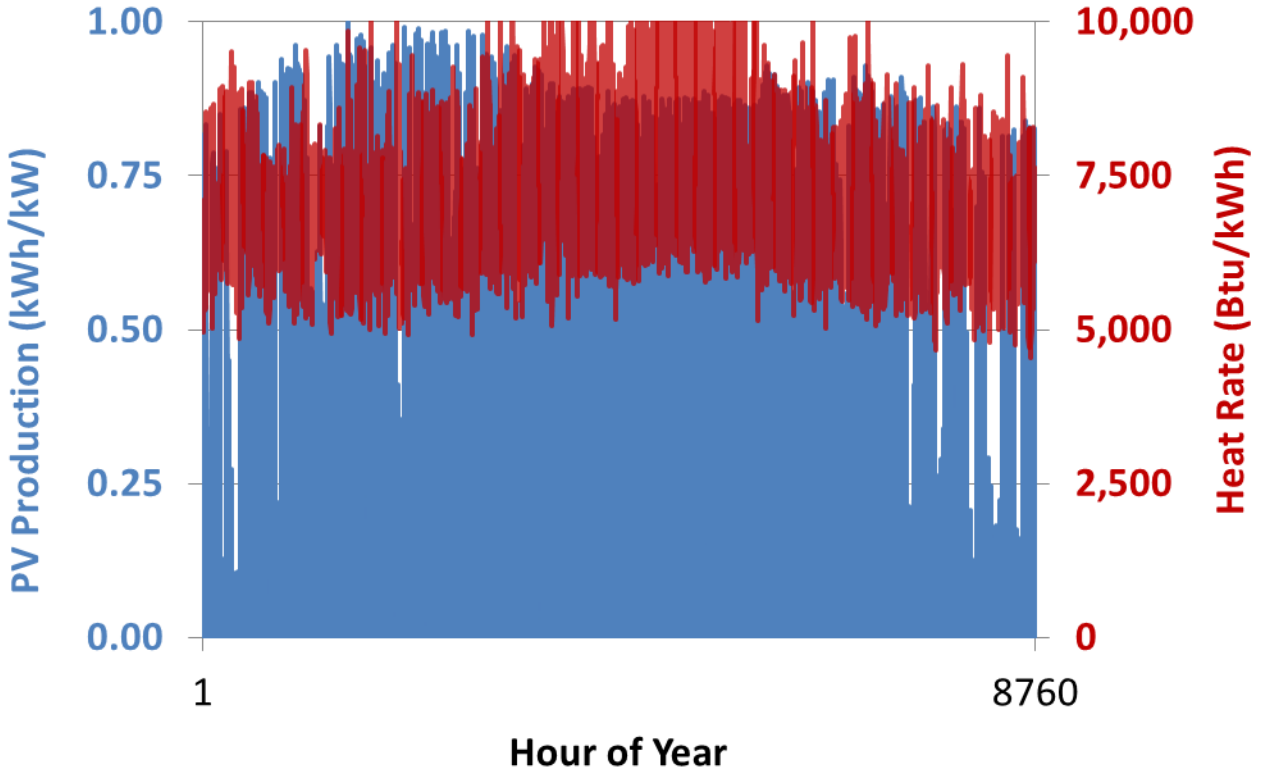
Option 2: Calculate ***Solar Weighted Heat Rate***
Obtain Hourly Production For Representative PV Fleet



Combine With Hourly Heat Rates

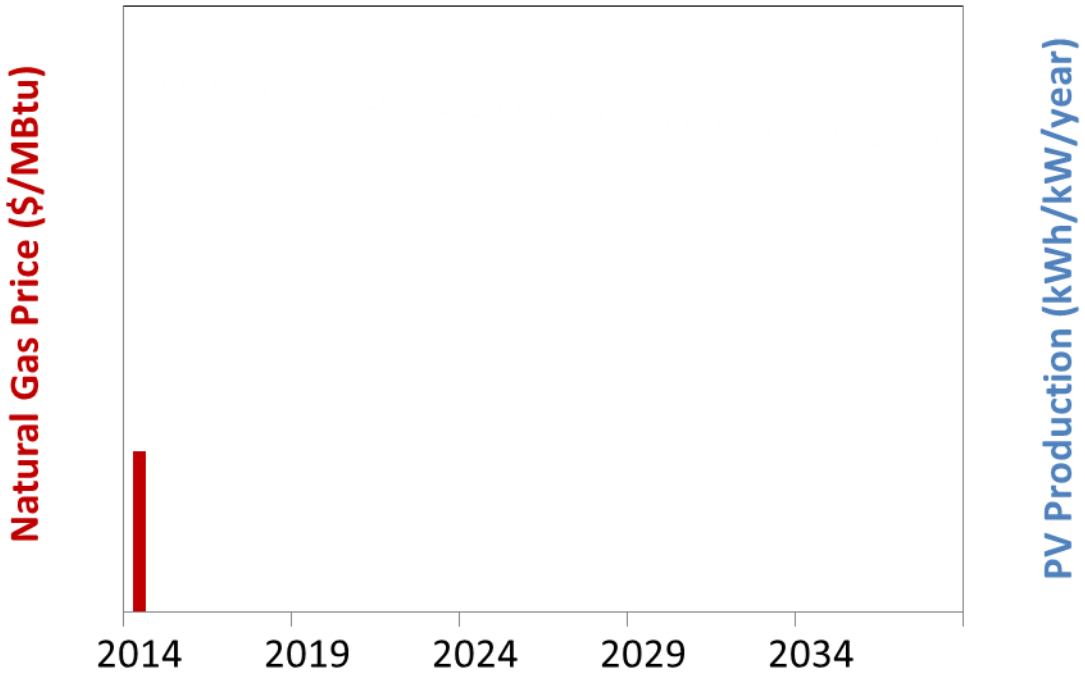


Repeat For All Hours Of Year

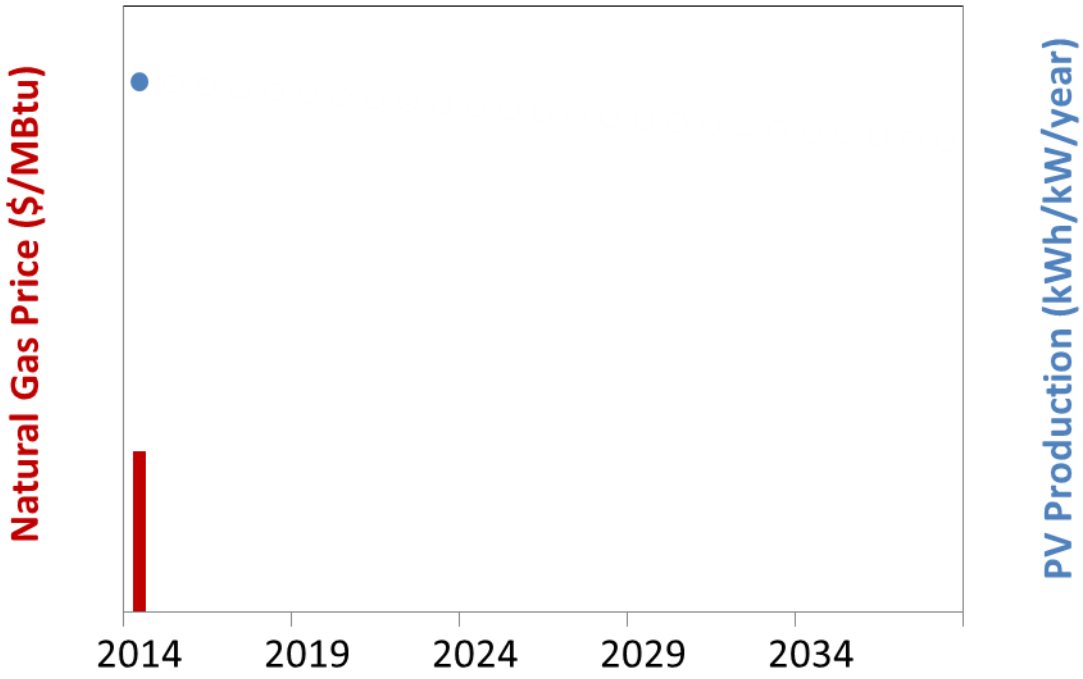


Solar Weighted Heat Rate = Sum the product of hourly marginal heat rate and PV production and divide by sum of PV production

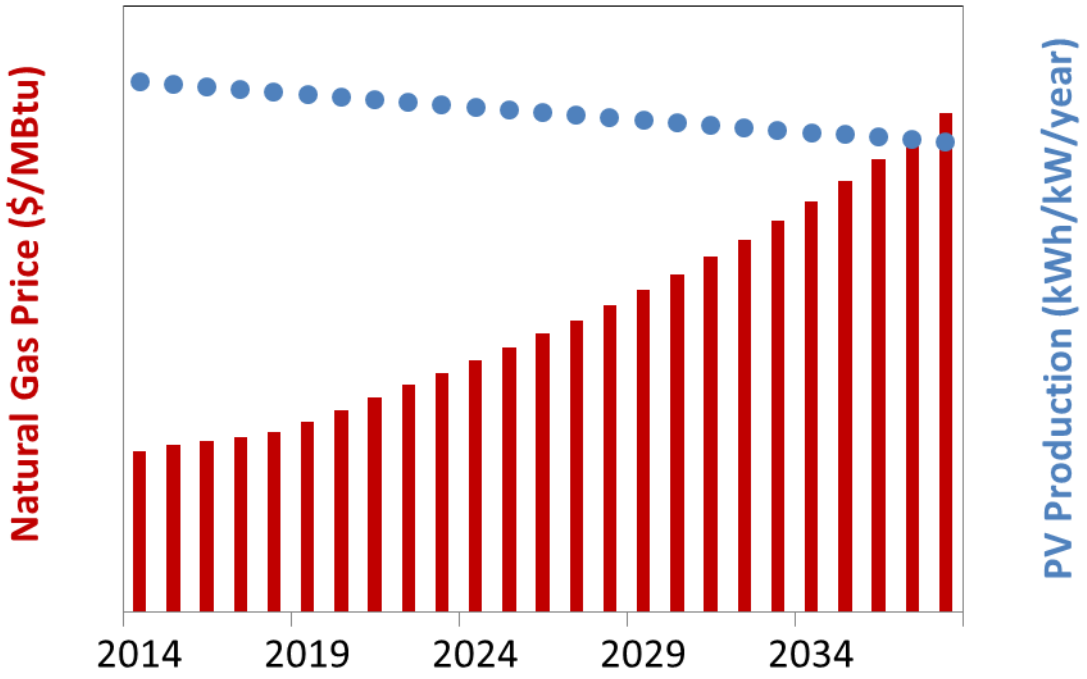
Obtain Natural Gas Prices



Combine With Annual PV Production and Solar Weighted Heat Rate



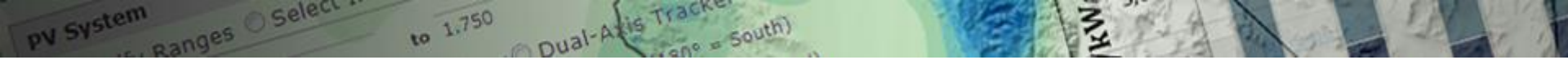
Repeat For All Years And Discount Result



Sum the product of ***NG Price***, ***Annual PV Production***, ***Solar Weighted Heat Rate*** and ***Discount Rate*** and then levelize the result

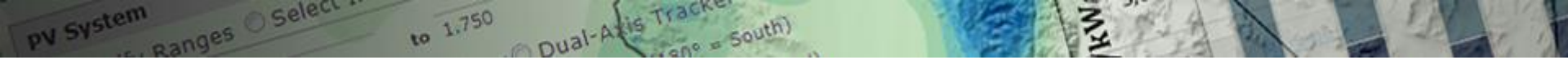
What Is Fuel Price Guarantee?

- Definition
  - Benefit that distributed PV generation has no fuel price uncertainty
- Methodology
  - Calculated by determining how much it would cost to eliminate the fuel price uncertainty associated with natural gas generation



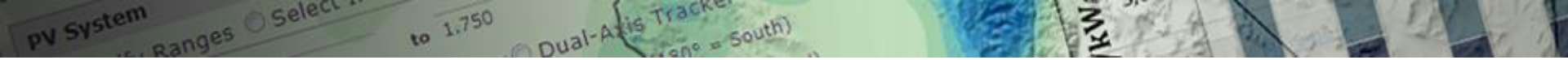
How Do You Eliminate Uncertainty?

- Eliminate uncertainty in the input assumptions, especially natural gas prices and discount rates



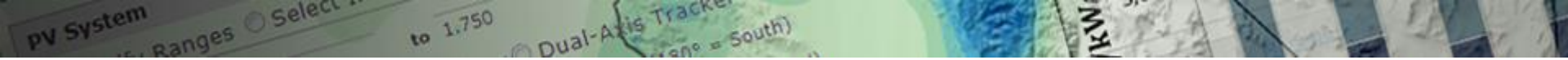
How Can Natural Gas Price Uncertainty Be Eliminated?

- Natural gas futures contract prices escalated at some agreed upon rate after point at which natural gas futures contracts are not available (Source: http://quotes.ino.com/exchanges/contracts.html?r=NYMEX_NG)
- Firm quoted price for utility to execute long-term contract with a natural gas supplier
- Stakeholders recommended that one alternative would be “utility-guaranteed 25-year fuel price (i.e., removed from the fuel adjustment mechanism and established as a fixed cost in base rates)”



How Discount Rate Uncertainty Be Eliminated?

- Use discount rates associated with federal government Treasury Yield Curve
- Source: www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield



Combine Avoided Fuel Cost and Fuel Price Guarantee

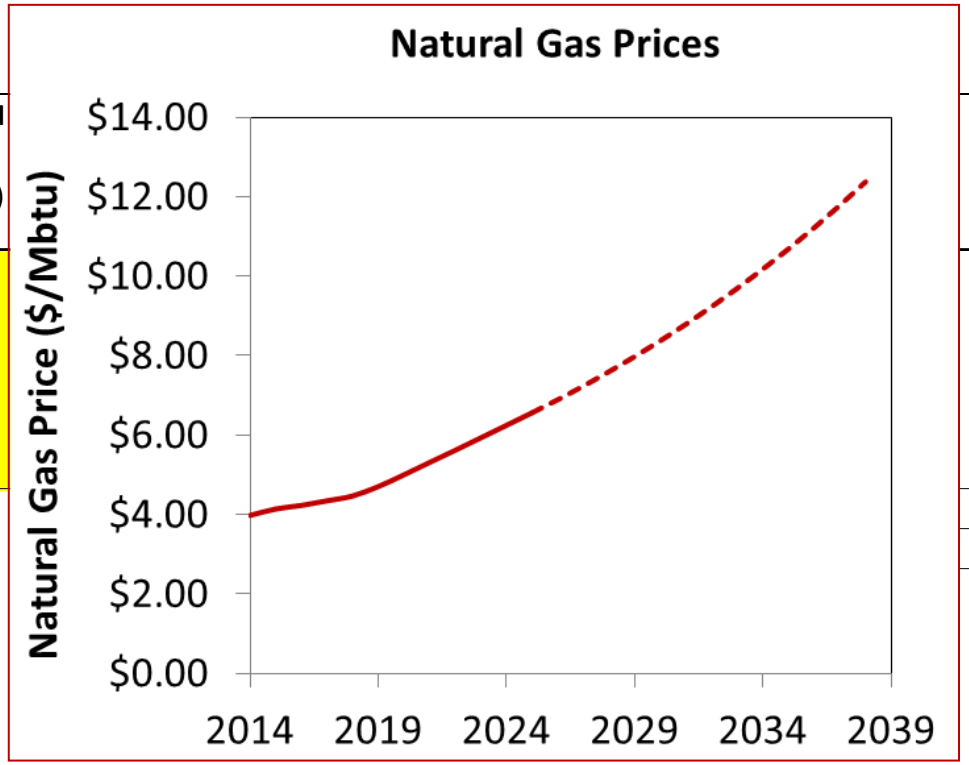
- Stakeholders recommended that the DOC "combine the 'Fuel Price Guarantee' value component with the fuel component"
- They also recommended that "the value of the solar generation fuel price guarantee accrues directly to ratepayers rather than indirectly (through base rates) should not be a reason to exclude this value component."
- These recommendations make sense to CPR. The next several slides illustrate how this calculation would work if the combined value (Avoided Fuel Cost and Guaranteed Fuel Value) uses the Avoided Fuel Cost approach (described above) with inputs of ***guaranteed*** natural gas prices and ***guaranteed*** discount rates

Guaranteed Fuel Value Calculations

Year											
2014											
2015											
2016											
…											
2037											
2038											

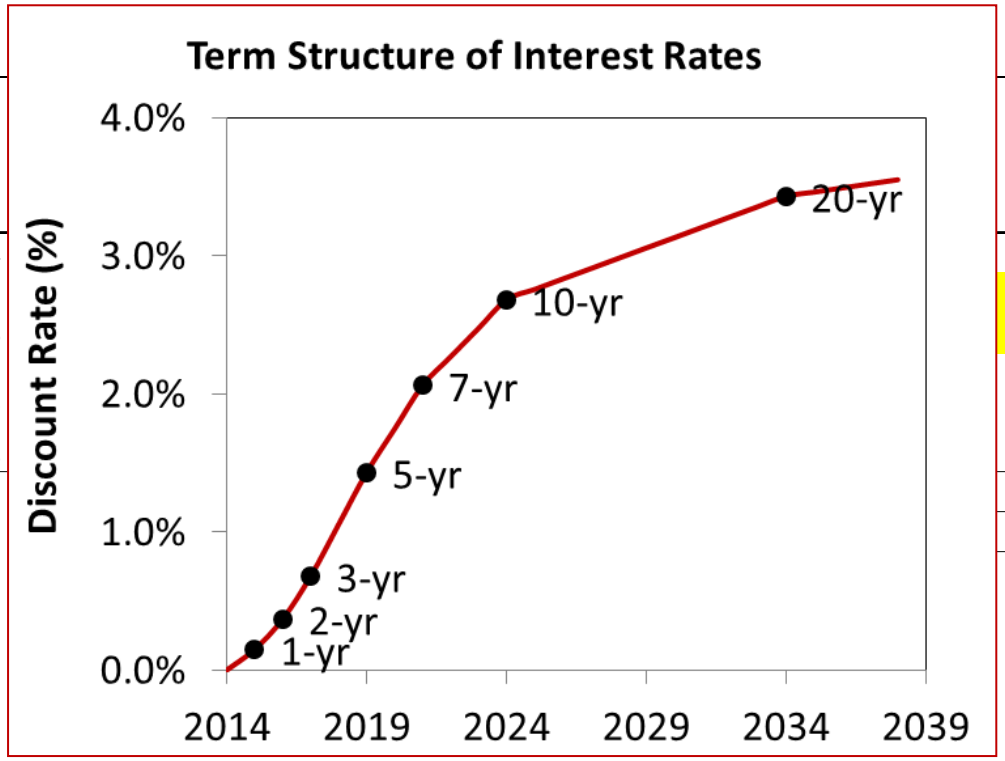
Obtain Guaranteed Natural Gas Prices

Year	Guaranteed NG Price ($/ MMBtu)
2014	$3.98
2015	$4.14
2016	$4.23
…	…
2037	$11.79
2038	$12.38



Assume 5% escalation after 2025

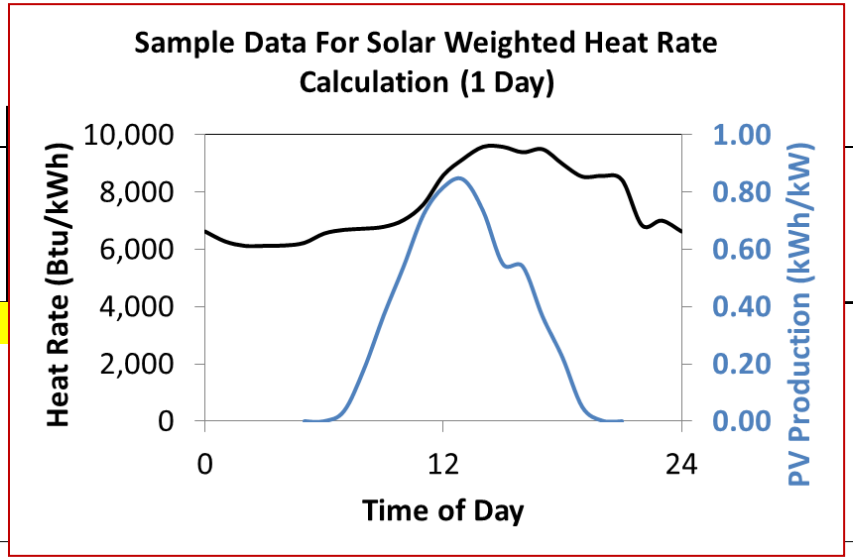
Obtain Guaranteed Interest Rates

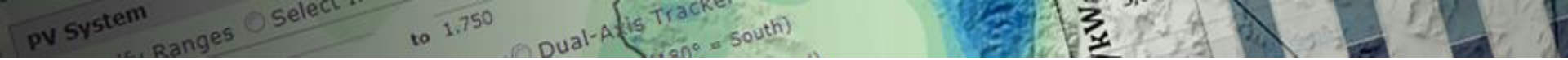


Year	US Treas. Yield Curve
2014	0.15%
2015	0.37%
2016	
…	
2037	
2038	

Obtain Solar Weighted Heat Rate

Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)
2014	$3.98	8200
2015	$4.14	
2016	$4.23	
…	…	
2037	$11.79	
2038	$12.38	





Obtain PV Performance Data

Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)						US Treas. Yield Curve			
2014	$3.98	8200									
2015	$4.14							0.15%			
2016	$4.23							0.37%			
…	…										
2037	$11.79										
2038	$12.38										

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

PV Capacity Factor and Degradation

Calculate and Extend Results

Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)			PV Prod. (kWh/ kWdc/yr)			US Treas. Yield Curve	Discount Factor		
2014	$3.98	8200			1,314			0.00%	1.000		
2015	$4.14	8200			1,307			0.15%	0.999		
2016	$4.23	8200			1,301			0.37%	0.993		
…	…	…			…			…	…		
2037	$11.79	8200			1,171			3.52%	0.451		
2038	$12.38	8200			1,165			3.55%	0.433		

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Calculate Utility Generation Price

Utility Generation Price = Guaranteed NG Price x Solar Weighted Heat Rate / 10^6

			Prices							
Year	**Guaranteed NG Price** ($/ MMBtu)	**Heat Rate** (Btu/kWh)	**Utility Gen.** ($/kWh)		**PV Prod.** (kWh/ kWdc/yr)			**US Treas. Yield Curve**	**Discount Factor**	
2014	$3.98	8200	$0.033		1,314			0.00%	1.000	
2015	$4.14	8200	$0.034		1,307			0.15%	0.999	
2016	$4.23	8200	$0.035		1,301			0.37%	0.993	
…	…	…	…		…			…	…	
2037	$11.79	8200	$0.097		1,171			3.52%	0.451	
2038	$12.38	8200	$0.101		1,165			3.55%	0.433	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Calculate Utility Generation Fuel Savings

Utility Generation Fuel Savings = Utility Generation Price x PV Production

			Prices			Fuel Savings				
Year	**Guaranteed NG Price** ($/ MMBtu)	**Heat Rate** (Btu/kWh)	**Utility Gen.** ($/kWh)		**PV Prod.** (kWh/ kWdc/yr)	**Utility Gen.** ($)		**US Treas. Yield Curve**	**Discount Factor**	
2014	$3.98	8200	$0.033		1,314	$43		0.00%	1.000	
2015	$4.14	8200	$0.034		1,307	$44		0.15%	0.999	
2016	$4.23	8200	$0.035		1,301	$45		0.37%	0.993	
…	…	…	…		…	…		…	…	
2037	$11.79	8200	$0.097		1,171	$113		3.52%	0.451	
2038	$12.38	8200	$0.101		1,165	$118		3.55%	0.433	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Calculate Discounted Utility Generation Fuel Savings Value

Discounted Utility Gen. Fuel Savings = Utility Gen. Fuel Savings x Discount Factor

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	**Guaranteed NG Price** ($/ MMBtu)	**Heat Rate** (Btu/kWh)	**Utility Gen.** ($/kWh)		**PV Prod.** (kWh/ kWdc/yr)	**Utility Gen.** ($)		**US Treas. Yield Curve**	**Discount Factor**	**Utility Gen.** ($)	
2014	$3.98	8200	$0.033		1,314	$43		0.00%	1.000	$43	
2015	$4.14	8200	$0.034		1,307	$44		0.15%	0.999	$44	
2016	$4.23	8200	$0.035		1,301	$45		0.37%	0.993	$45	
…	…	…	…		…	…		…	…	…	
2037	$11.79	8200	$0.097		1,171	$113		3.52%	0.451	$51	
2038	$12.38	8200	$0.101		1,165	$118		3.55%	0.433	$51	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Calculate Present Value Utility Generation Fuel Savings

Present Value = Sum of Discounted Utility Gen. Fuel Savings

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)	Utility Gen. ($/kWh)		PV Prod. (kWh/ kWdc/yr)	Utility Gen. ($)		US Treas. Yield Curve	Discount Factor	Utility Gen. ($)	
2014	$3.98	8200	$0.033		1,314	$43		0.00%	1.000	$43	
2015	$4.14	8200	$0.034		1,307	$44		0.15%	0.999	$44	
2016	$4.23	8200	$0.035		1,301	$45		0.37%	0.993	$45	
…	…	…	…		…	…		…	…	…	
2037	$11.79	8200	$0.097		1,171	$113		3.52%	0.451	$51	
2038	$12.38	8200	$0.101		1,165	$118		3.55%	0.433	$51	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Present Value	**$1,220**

Infer VOS Guaranteed Fuel Value

Select VOS Fuel Value that makes utility economically indifferent on present value basis

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	**Guaranteed NG Price** ($/ MMBtu)	**Heat Rate** (Btu/kWh)	**Utility Gen.** ($/kWh)	**VOS Fuel Value** (Levelized $/kWh)	**PV Prod.** (kWh/ kWdc/yr)	**Utility Gen.** ($)		**US Treas. Yield Curve**	**Discount Factor**	**Utility Gen.** ($)	
2014	$3.98	8200	$0.033	**$0.054**	1,314	$43		0.00%	1.000	$43	
2015	$4.14	8200	$0.034	**$0.054**	1,307	$44		0.15%	0.999	$44	
2016	$4.23	8200	$0.035	**$0.054**	1,301	$45		0.37%	0.993	$45	
…	…	…	…	**…**	…	…		…	…	…	
2037	$11.79	8200	$0.097	**$0.054**	1,171	$113		3.52%	0.451	$51	
2038	$12.38	8200	$0.101	**$0.054**	1,165	$118		3.55%	0.433	$51	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Present Value	**$1,220**

Calculate VOS Fuel Savings

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)	Utility Gen. ($/kWh)	VOS Fuel Value (Levelized $/kWh)	PV Prod. (kWh/ kWdc/yr)	Utility Gen. ($)	VOS ($)	US Treas. Yield Curve	Discount Factor	Utility Gen. ($)	
2014	$3.98	8200	$0.033	$0.054	1,314	$43	$71	0.00%	1.000	$43	
2015	$4.14	8200	$0.034	$0.054	1,307	$44	$70	0.15%	0.999	$44	
2016	$4.23	8200	$0.035	$0.054	1,301	$45	$70	0.37%	0.993	$45	
…	…	…	…	…	…	…	…	…	…	…	
2037	$11.79	8200	$0.097	$0.054	1,171	$113	$63	3.52%	0.451	$51	
2038	$12.38	8200	$0.101	$0.054	1,165	$118	$63	3.55%	0.433	$51	

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Present Value	$1,220

Discount VOS Fuel Savings

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)	Utility Gen. ($/kWh)	VOS Fuel Value (Levelized $/kWh)	PV Prod. (kWh/ kWdc/yr)	Utility Gen. ($)	VOS ($)	US Treas. Yield Curve	Discount Factor	Utility Gen. ($)	VOS ($)
2014	$3.98	8200	$0.033	**$0.054**	1,314	$43	$71	0.00%	1.000	$43	$71
2015	$4.14	8200	$0.034	**$0.054**	1,307	$44	$70	0.15%	0.999	$44	$70
2016	$4.23	8200	$0.035	**$0.054**	1,301	$45	$70	0.37%	0.993	$45	$70
…	…	…	…	**…**	…	…	…	…	…	…	…
2037	$11.79	8200	$0.097	**$0.054**	1,171	$113	$63	3.52%	0.451	$51	$28
2038	$12.38	8200	$0.101	**$0.054**	1,165	$118	$63	3.55%	0.433	$51	$27

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Present Value	**$1,220**

Calculate Present Value VOS Fuel Savings

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)	Utility Gen. ($/kWh)	VOS Fuel Value (Levelized $/kWh)	PV Prod. (kWh/ kWdc/yr)	Utility Gen. ($)	VOS ($)	US Treas. Yield Curve	Discount Factor	Utility Gen. ($)	VOS ($)
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2016	$4.23	8200	$0.035	**$0.054**	1,301	$45	$70	0.37%	0.993	$45	$70
…	…	…	…	…	…	…	…	…	…	…	…
2037	$11.79	8200	$0.097	**$0.054**	1,171	$113	$63	3.52%	0.451	$51	$28
2038	$12.38	8200	$0.101	**$0.054**	1,165	$118	$63	3.55%	0.433	$51	$27

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Present Value	**$1,220**	**$1,220**

Validate

			Prices			Fuel Savings				Disc. Fuel Savings	
Year	Guaranteed NG Price ($/ MMBtu)	Heat Rate (Btu/kWh)	Utility Gen. ($/kWh)	VOS Fuel Value (Levelized $/kWh)	PV Prod. (kWh/ kWdc/yr)	Utility Gen. ($)	VOS ($)	US Treas. Yield Curve	Discount Factor	Utility Gen. ($)	VOS ($)
2014	$3.98	8200	$0.033	**$0.054**	1,314	$43	$71	0.00%	1.000	$43	$71
2015	$4.14	8200	$0.034	**$0.054**	1,307	$44	$70	0.15%	0.999	$44	$70
2016	$4.23	8200	$0.035	**$0.054**	1,301	$45	$70	0.37%	0.993	$45	$70
…	…	…	…	**…**	…	…	…	…	…	…	…
2037	$11.79	8200	$0.097	**$0.054**	1,171	$113	$63	3.52%	0.451	$51	$28
2038	$12.38	8200	$0.101	**$0.054**	1,165	$118	$63	3.55%	0.433	$51	$27

Capacity Factor	15.0%
Degradation (%/yr)	0.5%

Validation: Present Value	**$1,220**	**$1,220**